SCIENCE

MARCH 6, 1953

VOLUME 117 NUMBER 3036

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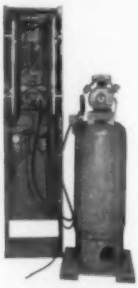

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THE Gulf Research & Development Company, a wholly owned subsidiary of the Gulf Oil Corporation, is situated near Harmarville, Pennsylvania, on a tract overlooking the Allegheny River, 15 miles northeast of downtown Pittsburgh. Of its 1280 employees, approximately 450 are scientists and engineers, 365 are technicians, and 465 nontechnical or service personnel. In addition, the research organization directs and coordinates the activities of nearly 900 people engaged in geophysical exploration in the United States, Canada, Europe, Africa, and South America.

Practically all the research activities of the parent corporation are carried on in the laboratories of Gulf Research. In concentrating research and development on all phases of petroleum technology, from exploration to refining and product development, Gulf Oil has adopted a course unique among large integrated oil companies. Other companies have customarily located their exploration and production laboratories in major oil-producing areas, and their process and product research near principal refineries. Today, with crude oil production a worldwide operation, and communication and transportation at high stages of advancement, Gulf feels that there is no disadvantage in locating its combined research facilities near Pittsburgh, the headquarters of the company. Indeed, there is a distinct advantage in bringing together at one place the ideas, experience, and training of technical people with backgrounds in all branches of science, engineering, and petroleum technology.

The research organization consists of eleven major divisions, with ten of them engaged in research and development work, and the eleventh responsible for the business and nontechnical service functions of the laboratory. Among the technical divisions is one involving a fellowship at the Mellon Institute of Industrial Research, engaged in fundamental research.

The ten research divisions are concerned with geophysical methods and instrumentation; petroleum geology; well-drilling equipment and techniques; oil reservoir engineering; corrosion, metallurgy, and materials testing; crude oil evaluation; refinery technology; chemical manufacturing processes; economic studies on chemical and refinery processes; development of analytical and testing procedures; automotive, marine, aircraft, and diesel engine research; and the development of petroleum fuels and lubricants.

One division, responsible for all geophysical exploration in the field, equips and directs 50 field parties scattered throughout the world. Field data gathered by these parties are analyzed at the laboratory and lead to recommendations for leasing land and drilling wells. Gulf was not only a pioneer in geophysics and reservoir engineering, but was the first of the oil companies to recognize the importance of applied physics in solving technical problems of the industry.

The Gulf Laboratory, established at its present site in 1935, now has 19 buildings for research and development, and again as many auxiliary or service buildings. Testing and analytical equipment is of the latest design and includes all types of spectrographs, two mass spectrometers, and an electron microscope. Constant-temperature rooms ranging from $-30°$ F to $+130°$ F are available, with some large enough to accommodate full-scale test engines. Two road-test chassis dynamometers make it unnecessary to drive test cars on public highways under adverse weather and traffic conditions. A large, well-equipped machine shop builds special research equipment and makes most of the complex instruments used in geophysical field operations. Six expert glassblowers, equipped with the most modern glassblowing tools, fabricate the intricate glass apparatus used in research. Excellent technical information service is furnished with the aid of a 15,000-volume library.

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Pittsburgh, Pennsylvania

SCIENCE, founded in 1880, is published each Friday by the American Association for the Advancement of Science at the Business Press, 10 McGovern Ave., Lancaster, Pa. Entered as second-class matter at the Post Office at Lancaster, Pa., January 13, 1948, under the Act of March 3, 1879. Acceptance for mailing at the special rate postage provided for in the Act of February 28, 1925, embodied in Paragraph (d-2) Section 34.40 P. L. & R. of 1948.

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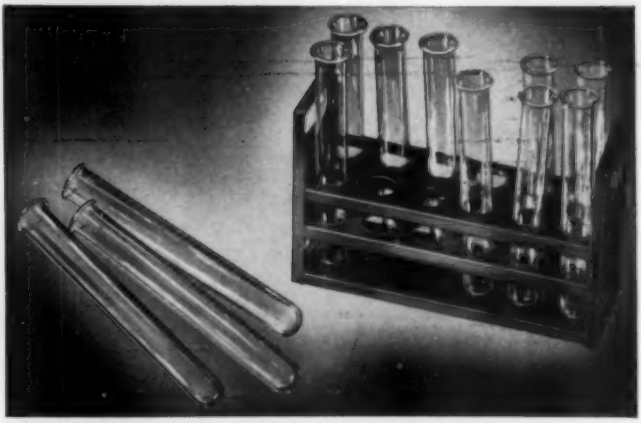

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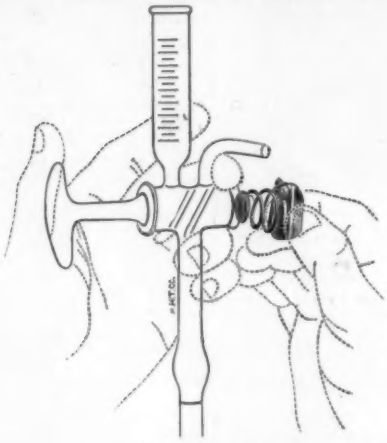

3291-B. Fig. 1.
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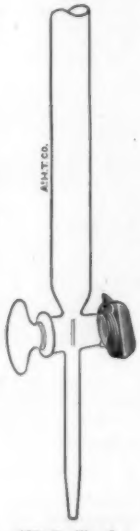
3291-B. Fig. 2.
Rear view, showing spring opposed jaws.



3291-B. Fig. 3.
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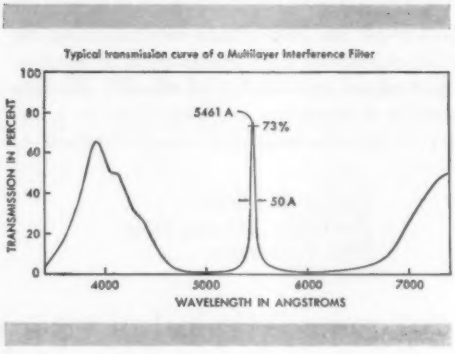

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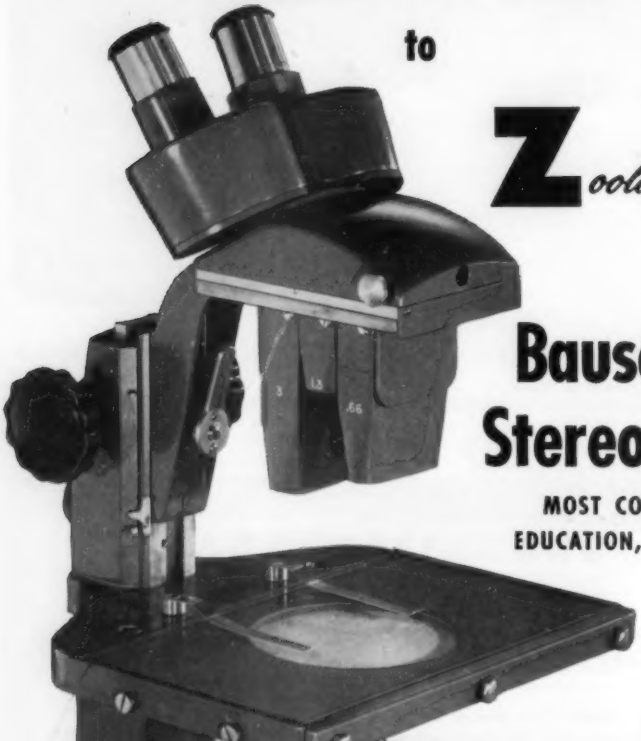

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Porpoise Sounds as Sonar Signals[1,2]

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Oceanographic Institute, Florida State University, Tallahassee, and
U. S. Air Force Guided Missile Center, Cocoa, Florida

THE NOTION that porpoises or dolphins—and possibly other cetaceans as well—orient themselves in the water by listening to the reflected echoes of their own noises offers challenging possibilities for research (*1, 2*). This process, known as echolocation or echo-ranging, serves as the basis of sonar, and of both sonic and supersonic depth-finding. The best example of echolocation among animals is the case of the bat, which is known to employ reflected sound to avoid colliding with objects while in flight. Griffin (*3, 4*) has shown, in fact, that the cries emitted by bats for purposes of echo-ranging extend far into the ultrasonic range.

The study of such a phenomenon in animals of the sea involves special problems of its own—particularly since scientific knowledge on this question is at present extremely meager. In order to determine whether porpoises or dolphins employ echo-ranging in water, it would certainly be necessary to establish three things: First, it must be shown that these animals can hear sufficiently well and in the proper frequency range to react to the echoes of the sounds they emit; second, it must be demonstrated that the noises fall within a temporal and frequency pattern suitable for echo-ranging in water; third, it must be established that, even though they possess these mechanisms, they actually employ them to orient themselves in space and to avoid colliding with objects in their environment.

With regard to the first point, Fraser (*5*) has noted that certain porpoises will swim rapidly away from a vessel at the sound of a supersonic depth finder—a reaction which clearly implies that they can hear sounds higher than man. Whether such hearing actually exists, and the limits to which it may extend, have recently been investigated (*2*) by two of the present writers in tests upon the bottle-nose dolphin, *Tursiops truncatus* (Montagu). The results indicate that under favorable conditions this animal can regularly react to vibrations in water as high as 80,000 cycles/sec.

As a consequence of these findings, interesting questions at once arise regarding the second point. For example, if *T. truncatus* is able to respond to frequencies in water at such a high level, what kinds of sounds does he himself produce, and are they also ultrasonic? That porpoises make a variety of noises has often been observed (*6–8*), but the problem of their measurement and analysis is not an easy one. In the present paper we wish to report some beginnings in this direction and to show that the sounds emitted by these remarkable animals can conceivably be used for echo-ranging or echolocation in water.

Subjects. All the subjects were bottle-nose dolphins, or porpoises, *T. truncatus*. Three of the animals were captive specimens; others were in the free or wild state. The wild porpoises were all observed from a U. S. Navy plane personnel boat, 24 feet in length, in the Gulf of Mexico, near the laboratory of the Oceanographic Institute of Florida State University. Two of the captive animals were young but mature females, which were studied at the Lerner Marine Laboratory at Bimini, B. W. I., a field station of the American Museum of Natural History. They were kept together in a wire enclosure in the open bay (*ca.* $30' \times 50'$), through which sea water flowed freely. The depth of the water at low tide was 7–8 feet, and at high tide 10–11 feet. The third captive animal was confined alone in an excavated canal or pool (*ca.* $40' \times 60'$) at the Daytona Sea Zoo at Daytona Beach, Florida. It was probably also a female.

Apparatus. The sounds were picked up through a specially constructed hydrophone, or underwater microphone, capable of receiving vibrations up to and beyond 200,000 cycles/sec (200 kc). The hydrophone consisted of thick Rochelle salt blocks potted in clear plastic bonded to a brass cylinder containing a two-stage preamplifier. The signal from the preamplifier was fed into the medium-gain input stage of a high-fidelity power amplifier. Many of the sounds, after being received in this manner, were then recorded by means of an Ampex Model 307 high-speed tape recorder of the type ordinarily used in telemetering. The Ampex recorder has a rated recording range to 100,000 cycles/sec (tape speed, 60 in./sec) but will go considerably higher than this (although at reduced sensitivity). The response of the amplifier-recorder system as a whole was down approximately 3 db at 80,000 cycles/sec, and 5 or 6 db at 100,000 cycles/sec.

Methods of frequency analysis. Three general methods were used to determine the frequencies of the sounds emitted. None of these can be considered pre-

[1] Contribution No. 15 from the Oceanographic Institute of Florida State University.

[2] The research as a whole was sponsored by the Office of Naval Research under contract Nonr 531 (00), and was aided by a grant-in-aid from the Research Council of Florida State University. Indispensable to its progress have been the continuous cooperation and generous help of Harold J. Humm, director of the Oceanographic Institute.

[3] The writers wish to take this opportunity to thank C. M. Breder, Jr., of the American Museum of Natural History in New York City, for permission to use the excellent facilities of the Lerner Marine Laboratory, a field station of the Museum at Bimini, in the Bahama Islands, B. W. I. We also wish to thank Perry A. Sperber and Mrs. M. R. Sperber, of the Daytona Sea Zoo, for generous cooperation and aid. The acoustical analysis was greatly facilitated by the cooperation of the U. S. Air Force Guided Missile Center at Cocoa, Fla., and the U. S. Navy Mine Countermeasures Station at Panama City, Fla.

cise, but they do show the presence or absence of vibrations within different frequency bands and they also indicate the relative intensities of the waves that are present.

1. In the first of these methods the porpoise sounds, after being received by the hydrophone and amplified, were sent through band-pass or high-pass filters and observed on the screen of a cathode-ray oscilloscope. One such filter was an SKL variable electronic Model 302. The SKL filter is adjustable, permitting the passing of any desired frequency band from 0 to 200 kc. When the lower frequencies were filtered out, the presence of the higher frequencies could be seen directly on the oscilloscope screen at the same time that the noises were being produced. A loudspeaker permitted the simultaneous hearing of the audible component of the sounds. Another type of filter, employed particularly in studies of the wild porpoises in the Gulf, was a high-pass, high-Q filter which cut out all frequencies below 100 kc.

2. The second method was a variation of the first, yet it afforded the opportunity for more careful and deliberate work. In this case ultrasonic tape recordings obtained from the captive animals were played back on the Ampex recorder in the laboratory. The signals from the recorder were then sent through the SKL filter and were observed on an oscilloscope as in method one. This procedure permitted repeated playbacks of the same sounds under favorable laboratory conditions, with the consequent opportunity of checking and rechecking the results obtained.

3. The third and most elaborate of the techniques for determining the frequencies within the total sound complex made use of (*a*) a Panoramic Ultrasonic Analyzer, Model SB-7, and (*b*) the Fairchild Sound Measuring and Analyzing System of the U. S. Navy Mines Countermeasures Station, at Panama City, Florida.

a) The Panoramic Ultrasonic Analyzer is a scanning heterodyne receiver which automatically measures the frequency and amplitude of both sonic and ultrasonic signals. Using a stabilized sweeping system, "... the instrument tunes repetitively 6 times per sec through a 200 kc range in any part of a 10 kc to 300 kc band. As signals are tuned through, they appear on a cathode-ray tube as sharp vertical pips located horizontally in order of frequency. The heights of the pips indicate the relative magnitudes of their corresponding signals. A continuous over-all graphic presentation of the spectrum is obtained on a long persistence cathode-ray tube screen."[4] The signals from the tape of the Ampex recorder were fed directly into this device. A speaker was also in the circuit, so that the audible components of the sounds could be heard simultaneously with the occurrence of their pips upon the cathode-ray screen.

b) The Fairchild Sound Measuring and Analyzing System used in the frequency analysis is a special octave band-pass analyzing system manufactured by the Fairchild Instrument Company. The input signals are broken down into the octave bands by individual band-pass amplifiers having a maximum gain of 86 db. The filters are flat to ± 1.0 db over one half of each octave band. At the cutoff points of the octave, the level is down 6 db from the center level, and the cutoff rate outside the octave band is 45 db/octave. The signals from Ampex tape recordings, after passing through the octave-band amplifiers of the Fairchild system, were read from a Dumont Model 304 oscilloscope and from a Ballentine a-c meter Model 310.

[4] Statement from manufacturer.

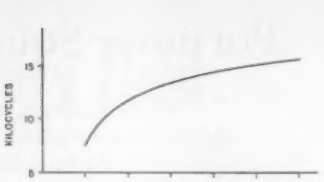

FIG. 1. Schematic diagram of one form of the porpoise whistle, showing frequency plotted against time.

The findings discussed here will deal only with the temporal and frequency characteristics of the noises made and will ignore any absolute measures of intensity. The reasons for this limitation are (*a*) that the receiving system as a whole was an uncalibrated system so far as intensities are concerned. (*b*) Yet, even had it been calibrated, there was no way to keep the distance between the porpoises and the hydrophone constant. Since the intensity of sound varies inversely with the square of the distance from the source, a receiving system calibrated for intensities would therefore have been of little value in any case.

The system was carefully checked for its frequency responses, however, by sending pure tones from an oscillator through an underwater transducer, at 20–200,000 cycles/sec. The frequencies sent out by the transducer were then picked up by the hydrophone and amplifying equipment and were observed on the screen of a cathode-ray oscilloscope. The same frequencies were also sent directly to the oscilloscope, by-passing the underwater gear entirely. A comparison of the wave forms transmitted by these two methods showed that no distortions in frequency were introduced by the underwater system.

The porpoise whistle. Of the various noises produced by the bottle-nose dolphins observed in these studies, two were found to occur almost continuously. The first of these was a birdlike whistle, approximately .5 sec in duration. The whistle appeared in several "melodies," or pitch patterns, the most common of which resembled the cheep or whistle of a canary. This generally began in the neighborhood of 7000 cycles/sec and ended at about 15,000 cycles/sec. The pitch range was therefore slightly over an octave. Although harmonics are certainly present, we have not been able to bring them out well. The whistle overtones are apparently weak and, so far as we can determine, do not extend beyond 20 kc. This is something of a paradox, since the whistle is of course very high to human ears, and might consequently be expected to possess a strong component of ultrasonic vibrations. However, since the whistle does occur in several forms, there may be varieties of it, not yet examined, that contain harmonics beyond 20 kc. It is likely, moreover, that the whistles given by different individuals will vary considerably. A schematic representation, showing one form of the porpoise whistle, with frequency plotted against time, is given in Fig. 1.

If the bottle-nose dolphin employs reflected sound

to orient itself in space, the whistle could conceivably be used for this purpose. Under such circumstances it would constitute a kind of frequency-modulated sonar. The continuously changing pitch would reflect a continuously changing echo, which at any given instant would differ from the frequency being produced. With such a method it is not necessary that the sounds be emitted in short, intermittent bursts as they are in a pulse-modulated system.

Underwater "clicks." The second and by far the more common of the underwater sounds produced by the bottle-nose dolphin is a series of rapid "clicks" or "clacks," variously described as the "rusty-hinge" sound or the "creaking-door" sound. These sounds are also reminiscent of the pecking of a woodpecker, except that their rate of occurrence is usually faster, although it can also be slower than that of the woodpecker. One is similarly reminded of the Bronx cheer made by blowing air through tightly pressed human lips. The rate at which the individual clicks occur may vary from as slow as 5/sec to 100/sec, or higher. In the latter instance the total sound takes on the general quality of a groan or a bark. Within a single group of clicks lasting several seconds, the number of clicks per second can change from fast to slow, or vice versa. When these sounds occur at approximately 15/sec or slower, they lose any tonal quality they may have possessed, and are then heard as a succession of discrete individual units. In such cases each click becomes a sharp, staccato report, like that produced by striking a heavy wooden table with a small hammer.

Since the groan or barklike effect of a train of such clicks is ordinarily low in pitch, the average listener is not likely to suspect them of containing ultrasonic frequencies. Yet the methods of analysis previously described disclose them to be heavily weighted with such frequencies. The dominant frequencies, so far as intensity is concerned, are in the sonic range, but other vibrations far above the limits of audibility are present. With respect to the wide band of vibrations represented, the clicks somewhat resemble "white noise." Analysis of our Ampex recordings has shown a tapering off of intensities from 20 ke to about 120 ke, with the occasional occurrence of vibrations extending to 170 ke or higher.

The tapering effect beyond 100 ke is undoubtedly a function of the Ampex recorder, at least in part, since this instrument is known to fall off rapidly above 100 ke and is not even rated by the manufacturer for values higher than this level. At the same time, it may be due in some degree to the nature of the sounds themselves. So far as our observations have been able to go, it would appear that the different clicks each possess somewhere near the same complex of frequencies. Certainly we have been able to detect no significant variations in pitch from one click to the next. It must be concluded, therefore, that the click or clack emitted by the bottle-nose dolphin contains frequencies that extend to 120 ke or above.

Fig. 2 is a photograph of the cathode-ray screen of the ultrasonic analyzer, showing the frequency components occurring between 80 and 120 ke in a series of porpoise clicks. The 80 ke marker-pulse is the low peak on the left overlapping the higher peak on the left. Only those frequencies corresponding to the position of the sweep at the moment the sound occurred are shown. The separate peaks indicate the presence of frequencies within the different clicks, which correspond to the horizontal scale. In this particular instance, 12 clicks occurred during the .5-sec photographic exposure. The heights of the pips in the photograph show the relative intensities for the different frequencies.

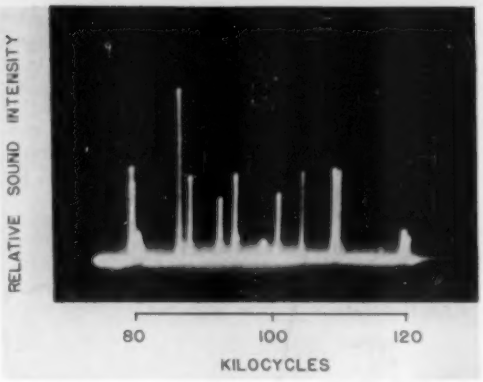

FIG. 2. Photograph of the cathode-ray screen of a panoramic ultrasonic analyzer, showing the frequency components occurring between 80 and 120 ke in a series of porpoise clicks. The separate pips represent the coincidence of the sweep of the cathode-ray tube with different clicks. The 12 clicks that occurred during the photographic exposure (.5 sec in this instance) thus contained frequencies extending at least to 120 ke.

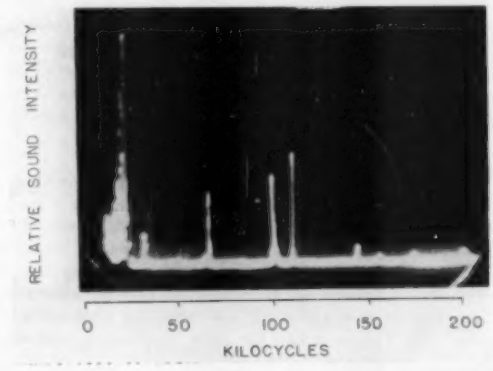

FIG. 3. Photograph of the cathode-ray tube of the panoramic analyzer when the tuning range was 10–200 ke. The strongest frequencies, so far as intensity is concerned, will be seen to lie below 25 ke, but the short pips at the right indicate the presence of frequencies at 140, 155, and 170 ke, respectively.

Fig. 3 is another photograph of the frequencies in porpoise clicks, when the tuning range of the analyzer was 10–200 ke. The 200 ke marker is the small pip on

the extreme right. A marker showing 100 kc appears as the heavier of the two central pips. It will be noted that there is a massing of frequencies below 25 kc in this sample. At the same time there are pips on the right representing frequencies of 140, 155, and 170 kc, respectively. Although these are the highest components we have thus far been able to photograph, there is no reason to believe that they represent the ultimate limit.[5]

It is possible to derive an approximate frequency spectrum for the ultrasonic frequencies of the clicking sounds by noting the amplitudes of the pips on the screen of the ultrasonic analyzer for a large number of individual clicks. Such a frequency spectrum would

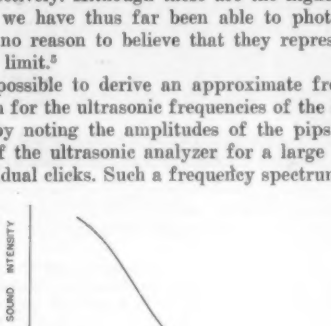

FIG. 4. Ultrasonic frequency spectrum derived from high-speed tape recordings of the typical porpoise click. Essentially the same graph was obtained by two independent methods of acoustical analysis.

indicate relative rather than absolute sound intensities, since these intensities are not only a function of the input signal but are also a function of the recording system. The spectrum derived in this way for frequencies higher than 20,000 cycles/sec is given in Fig. 4.

A similar curve has also been obtained by a different method of analysis. In this case Ampex recordings of dolphin sounds were run through a Fairchild Sound Measuring and Analyzing System, at the U. S. Navy Mine Countermeasures Station at Panama City. The graph obtained is again essentially that reproduced in Fig. 4.

Clicks as echo-ranging signals. Since the clicks do not vary systematically in frequency composition, they would be unsuitable for echo-ranging by a frequency-modulation method such as that applying to the whistle. But, on the other hand, a rapid succession of short impulses, of constant frequency pattern, would be excellent for echo-ranging, if time were allowed after each pulse for the reflecting back of its own echo. This is in fact the pulse-modulation method of echo-ranging.

So far as timing and duration are concerned, the clacks produced by the bottle-nose dolphin satisfy fully the requirements necessary for echo-ranging in water by the pulse-modulation method. The duration of the shortest of these sounds has been found to be about 1 msec (.001 sec). Others are considerably longer. At a water temperature of 82.5° F, and a salinity approximately that of the water at Bimini, for example, sound in sea water travels 5063 ft/sec. In .001 sec it would therefore travel a distance of 5.06 feet. This means that the initial vibrations of a single click .001 sec in length would be reflected back to the point of emission at the termination of that click, from an object as close as 2.53 feet. The speed with which a porpoise could react to this reflected signal would, of course, depend upon additional factors, such as, for example, its reaction time. But since the clicks are emitted in rapid succession, it is unlikely that the presence of any object would be sensed all at once. The approach to the object would be shown by a gradual change in the timing of the echo through many hundreds of successive impulses.

Most of the dolphins to which we have listened, or from which we have obtained recordings, have been found to be making such noises whenever the hydrophone was placed in the water. The sounds have been picked up when the animals were swimming slowly as well as when they were swimming fast, and sometimes when they were standing on their tails in the water, or were otherwise almost motionless. Such continuous sound production would be essential if the porpoises were regularly using these noises to locate objects in their environment.

Advantages of ultrasonic frequencies. Moreover, the wide band of frequencies represented in these noises offers special advantages for echo-ranging in water because of the factors of (*a*) masking and (*b*) resolution.

a) Under ordinary circumstances a porpoise may react to the sonic frequencies he produces, but in many instances these frequencies would be masked or obscured by the background water noise, which is mostly at lower frequency levels. Such noises as the sound of waves, the rushing of water past the animal's own body in fast swimming (like wind blowing by human ears), the sounds of ships' propellers, and the noises made by other organisms of the sea, are all, so far as is known, below 10,000 cycles/sec. When the basic porpoise frequencies are obscured or interfered with by such disturbances, the high-frequency components of the click would still filter through. It is possible in some cases that the ultrasonic frequencies alone would be all that could be heard.

b) High frequencies would also be better for echo-location because they are shorter in wavelength and consequently have a greater resolving power or directionality. They would indicate the presence, the size, and the shape of an object, by echoes, better than longer waves. A tone of 5000 cycles/sec, for example, if transmitted at a sound speed of 5000 ft/sec, produces a wave 1.0 feet in length. But if the frequency is increased to 50,000 cycles/sec, the sound speed remaining the same, the wavelength becomes 0.1 feet. The higher the vibration rate, the shorter the wavelength, and consequently the more precise the resolution as determined from the reflected echo.

[5] After the completion of this paper, an ONR report by Schevill and Lawrence (9) has reached us in which frequency components as high as 196 kc are reported in some porpoise sounds.

Listening to the echoes from clicks. Echoes from sounds made under water will bounce off from the surface of the water and from the bottom, as well as from objects located in a horizontal plane. That echoes of this sort are actually produced by porpoise clicks can be clearly demonstrated in two ways: (1) They can be seen on the screen of a cathode-ray oscilloscope. (2) They can be heard by the human ear under the proper acoustical and temporal conditions. The actual hearing of the echoes is accomplished by reducing the playback speed of the recording tape. The original tape speed of the Ampex ultrasonic recorder is 60 in./sec. Tests have been made with playback speeds of 1/8, 1/16, 1/32, and 1/64 of the recording rate. This has the effect of lowering the intensity as well as the number of cycles per second of the sounds played. For example, a bona fide frequency of 100,000 cycles/sec, reproduced at 1/64 of its original speed, becomes 1562.5 cycles/sec. The duration of the sound is correspondingly lengthened by a factor of 64.

Under such circumstances, the echo becomes clearly audible. It can be heard by most people at 1/16 of the recording speed, is very clear at 1/32, and is often a booming reverberation at 1/64 of the original rate. An inherent difficulty in measuring the duration of any single click is brought to light by this slow playback method, since a click cannot often be clearly separated from its own echo. One would have to be certain, in obtaining precise time measurements of this sort, that there was no echo at all—a difficult if not impossible prerequisite.

Although the facts recorded here do not establish conclusively that the bottle-nose dolphin actually uses echo-ranging, they offer good circumstantial evidence to that effect. *T. truncatus* certainly possesses what may be described as a "sonar system." The final proof that he employs it for echolocation must come by testing captive animals for the avoidance of objects in water after vision has been eliminated.

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News and Notes

Scientists in the News

James Bliss Austin, director of research and chief of U. S. Steel Company's Research Laboratory, Kearny, N. J., has been appointed chairman of the Committee on Chemical Warfare, U. S. Department of Defense, to succeed **Randolph T. Major,** vice president and scientific director of Merck & Co.

A. Ludlow Clayden has been appointed technical associate in Sun Oil Company's Chemical Research and Development Department. **John G. Moxey, Jr.,** succeeds him as manager of the Automotive Laboratory.

A. W. B. Cunningham, of the University of Edinburgh, has been appointed professor of pathology at the University of Texas Medical Branch, Galveston, where he will both teach and conduct research on arthritis and diseases of the joints.

Herbert N. Eaton retired on Jan. 31 as chief of the Hydraulics Section of the National Bureau of Standards, a position he has held since 1928. He had been with the bureau since 1919.

Gustav Egloff, petroleum scientist and director of research for Universal Oil Products Company, has been selected by five national engineering societies to receive the Washington Award for 1953, for leadership in petroleum research and in community services.

Nicholas Ercoli has been appointed head of the Department of Pharmacology and Chemotherapeutics, Research Division, Armour Laboratories, Chicago. Dr. Ercoli was formerly scientific director of the Istituto Sieroterapico Milanese Serafino Belfanti, University of Milan.

K. P. Ewing, entomologist of the U. S. Department of Agriculture, has been named head of the department's Division of Insects Affecting Cotton and other Fiber Plants. Mr. Ewing will succeed **R. W. Harned,** who will continue with the Bureau of Entomology and Plant Quarantine as staff assistant and consultant.

Herbert S. Gaskill, of the Indiana Medical School, Indianapolis, has been appointed professor and head of the Department of Psychiatry, University of Colorado, to succeed **Franklin G. Ebaugh,** who retired Jan. 1.

Blaine L. Glendening has been appointed principal chemist for the Kansas Public Health Laboratories, Topeka. He was formerly assistant chemist with the Kansas Agricultural Experiment Station.

Glenn C. Holm, member of the North Dakota Agricultural College Veterinary Department since 1949, has been named dean of agriculture and director of the Agricultural Experiment Station. Dr. Holm will succeed **H. L. Walster,** who will retire this spring.

S. D. Kirkpatrick, vice president of the McGraw-Hill Book Company, has been elected chairman of the AEC's Advisory Committee on Industrial Information. Mr. Kirkpatrick has served in the same capacity since 1949, having been appointed originally by the AEC general manager.

L. J. Klotz, chairman, Department of Plant Pathology, University of California Citrus Experiment Station, Riverside, will conduct studies in Sicily on the mal secco disease of lemons, a disease which does not occur in the lemon-producing areas of the U. S.

Jonathan D. Lankford has been appointed chief of the Region V Fuels Technology Division, Bureau of Mines, with headquarters at Minneapolis. Mr. Lankford succeeds **Alex C. Burr,** who will return to the directorship of the North Dakota Research Foundation, Bismarck, but will continue as consultant to the bureau.

Ivan N. Mensh was appointed associate professor and head of medical psychology in the Department of Neuropsychiatry, Washington University School of Medicine, St. Louis, effective Feb. 1.

Clark B. Millikan, Hans W. Liepmann, Frank E. Marble, and **Ernest E. Sechler,** of the California Institute of Technology faculty, have been reappointed to the National Advisory Committee for Aeronautics. **A. J. Stosick,** division chief of the Jet Propulsion Laboratory, owned by U. S. Army Ordnance and operated by Caltech, was appointed to the special subcommittee on rocket engines.

Norman Bartram Nelson, who has been dean of the School of Medicine, American University of Beirut, since 1951, has been named dean of the State University of Iowa College of Medicine, effective in July. Dr. Nelson served in Beirut while on leave from his post as assistant dean of the College of Medicine, University of California at Los Angeles.

William A. Sawyer, medical director of the Eastman Kodak Company since 1919, has been appointed head of the new Medical and Health Department, International Association of Machinists. The department will aid district and local lodges of the union with programs to provide prepaid health insurance for members.

Walter A. Schmidt, president and general manager of the Western Precipitation Company, Los Angeles, has been named honorary chairman of the American Chemical Society's 123rd national meeting, to be held in Los Angeles, Mar. 15–19.

Glenn T. Seaborg, director of chemical research at the Radiation Laboratory, University of California, and 1951 Nobel laureate, was selected to receive the John Scott Medal Award of the Board of City Trusts of Philadelphia. Dr. Seaborg was honored for his discovery of five of the transuranium elements—plutonium, americium, curium, berkelium, and californium.

Education

Boston College is offering a special intensive course in Modern Industrial Spectrography, July 20–31, designed particularly for chemists and physicists from industries in the process of installing spectrographic equipment. Full information may be obtained from James J. Devlin, of the Physics Department, Chestnut Hill 67, Boston.

The **University of Chicago** will offer the facilities of the Institute for Nuclear Studies and the Institute for the Study of Metals to Ph.D. candidates during the summer session, June 22–Aug. 29. Students in chemistry, physics, or related fields may, by special permission, carry on basic research in the institutes.

Duke University Marine Laboratory will offer a course in Oceanography June 15–July 18, under the direction of Donald W. Pritchard, director of the Chesapeake Bay Institute of Johns Hopkins University. Further information may be obtained from the director of the Duke Summer School.

Finch College, a junior college until last June, has added to its curriculum four-year courses leading to the B.S. and B.A. degrees. Numerous courses have been added in both biological and physical sciences. Recent appointments include Hugh E. Potts II as head of the Department of Biological Sciences and Roger H. Charlier as head of the Department of Physical Sciences and Mathematics. Marie H. Charlier will give new courses in physical and cultural geography and geology in 1953–54.

Grants and Fellowships

The **American Academy of Arts and Sciences** will receive applications for grants-in-aid of chemical research from its Cyrus M. Warren Fund until *Apr. 27.* Grants in excess of $300 are seldom made and are generally for apparatus and supplies needed for research; no funds are awarded for salaries. Application blanks will be sent upon request to the chairman of the grants committee, Edwin R. Gilliland, MIT, Cambridge 39, Mass.

The **Hamilton Memorial Foundation** has awarded a grant to the Evanston Hospital Laboratory, maintained under Northwestern University auspices. Studies on arteriosclerosis are under the direction of Arnold Wagner.

The **Louis W. and Maud Hill Family Foundation,** of St. Paul, Minn., has given $5700 to Carleton College for research in cell biology under the direction of Thurlo B. Thomas, chairman of the Department of Zoology.

The **Lasdon Foundation** has awarded $15,000 to Harvard Medical School and Peter Bent Brigham Hospital for support of research for the further study of the transplantation of vital organs, particularly kidneys, in human beings. George W. Thorn and Benjamin F. Miller are in charge of the work.

Eli Lilly and Company have approved three grants to Purdue University: to Henry Koffler for work on the intermediary metabolism of fungi; to C. L. Porter for investigation of antibiotics produced by certain microorganisms; and to M. G. Mellon for a study on colorimetric applications of heteropoly complexes.

The **National Paraplegia Foundation** is continuing, for the academic year 1953–54, a limited number of fellowships, at a minimum stipend of $3000 per year, for research in spinal cord disease and trauma. Application forms (returnable by *May 1*) and full information may be obtained from L. W. Freeman, chairman, Medical Advisory Committee, 1040 W. Michigan St., Indianapolis 7, Ind.

The **National Society for Crippled Children and Adults** and **Alpha Gamma Delta** are sponsoring 20 special fellowships for a four-week training program at the School of Education, New York University–Bellevue Medical Center. Applications (returnable before *Mar. 15*) and further information may be secured from the society, 11 S. La Salle St., Chicago 3.

Radio Corporation of America has awarded scholarships to 18 university students from 14 different states. Marijane Curran, of Stamford, Vt., a student at Wellesley College majoring in science, became the first woman to receive an RCA Scholarship.

Alfred P. Sloan National Scholarships, a new series of four-year undergraduate scholarships in technology and allied fields will be administered by California Institute of Technology, Carnegie Institute of Technology, Cornell University College of Engineering, and Massachusetts Institute of Technology. For the year 1953–54 only, all students who have applied for scholarship assistance at any of the participating institutions will be automatically considered for awards. Honorariums will range from $200 to $2000 per year, with an average allotment of $650 per year to each institution for each Sloan scholar.

In the Laboratories

Airborne Instruments Laboratory, Inc., has appointed Matthew T. Lebenbaum supervisor of its new Applied Electronics Section, and Peter D. Strum assistant supervising engineer.

Armour Research Foundation of Illinois Institute of Technology will reorganize and expand the State Industrial Research Institute of Burma, situated on the campus of Rangoon University. Christopher E. Barthel, Jr., assistant director of the foundation, will be resident director for the three-year program. He will leave for Burma in April.

General Motors Institute will add 83,000 square feet to its present facilities in Flint, Mich., adding approximately 40 per cent to classroom, laboratory, and general service areas. The institute will also remodel its present building, to allow greater emphasis in the curricula on the experimental approach to technological problems.

Arthur D. Little, Inc., will start construction Apr. 1 of a new Research Laboratory adjacent to its recently completed Mechanical Division building on the Concord Turnpike in West Cambridge, Mass.

Wisconsin's new million-dollar **State Laboratory of Hygiene** building, recently completed on the University of Wisconsin campus, was dedicated Feb. 28. Leonard A. Scheele, of the U. S. Public Health Service, delivered the chief address.

Meetings and Elections

A **conference on New Instruments Study Health and Disease** will be held by the Instrument Society of America, Mar. 16, 7:00 P. M., at the Midston House, New York. Kurt G. Stern, Harry Grundfest, and Raymond Jonnard will be the principal speakers; Joseph Greenspan is conference chairman.

A **Conference on Trends in Residential Air Conditioning** will be held Apr. 24–25 at Lehigh University. The Department of Mechanical Engineering is sponsoring the meeting in cooperation with the American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers, American Society of Mechanical Engineers, Air Conditioning and Refrigeration Machinery Association, National Association of Home Builders, Building Research Board, National Mineral Wool Association, and the National Warm Air Heating and Air Conditioning Association. James V. D. Eppes is chairman of the conference committee.

An **Institute on Medical History,** organized by the New York Academy of Medicine, will be held at Arden House, Harriman, N. Y., Mar. 13–14. The first day will be devoted to addresses by Alexander T. Martin, Alan Gregg, Paul Schrecker, Owsei Temkin, George Rosen, Erwin Ackerknecht, Gilbert Highet, John F. Fulton, Iago Galdston, Frank J. McGowan, and Gregory Zilboorg. The second day's program will be one of group discussions among the approximately 60 U. S. and Canadian participants.

The **International Association for Hydraulic Research** will hold a joint meeting with the Hydraulics Division of the American Society of Civil Engineers at the University of Minnesota, Aug. 30. Subjects to be discussed include density currents; air entrainment by flowing water; waves, beach erosion, and hydromechanics of shore structures; and basic relationships of sediment transportation of flowing water.

An **International Conference on the Science and Applications of Photography** will be held in London, Sept. 19–25, in celebration of the centenary of the Royal Photographic Society of Great Britain. The conference will be divided into sections dealing with photographic science (including theory of latent image and development, sensitization, sensitometry, resolving power, granularity, and properties of photographic materials); cinematography and color photography; technique and applications of photography; photo-

mechanical processes; and history, literature, and training in photography. Full details may be obtained from the Hon. Secretary, RPS Centenary Conference, 16 Princes Gate, London, S. W. 7.

Miscellaneous

Six members of the **American Chemical Society** have been selected for prizes and awards in recognition of outstanding achievement: Leo Brewer, University of California and consultant to the AEC, the Leo Hendrik Baekeland Award of the North Jersey Section; Robert Jenness, University of Minnesota, the Borden Award in the Chemistry of Milk; Donald D. Van Slyke, Brookhaven National Laboratory, the Fisher Award in Analytical Chemistry; Joel H. Hildebrand, University of California, the Willard Gibbs Medal of the ACS Chicago Section; Robert B. Anderson, U. S. Bureau of Mines, Bruceton, Pa., the Ipatieff Prize; and Robert W. Schiessler, Pennsylvania State College, the Precision Scientific Company Award in Petroleum Chemistry.

The **American League Against Epilepsy** has extended the time limit for submission of dissertations on any aspect of epilepsy for the Jerry Price Memorial Prizes from Apr. 1 to *July 1*. Inquiries from students of approved U. S. and Canadian medical schools may be addressed to William G. Lennox, 300 Longwood Ave., Boston 15; Francis L. McNaughton, 3801 University St., Montreal 2; or John L. Otto, 816 Strand, Galveston.

The fourth **Archbold Expedition** to New Guinea will spend nine months in the Papua area, making the first comprehensive survey of the flora and fauna of the region. The expedition will be led by Leonard J. Brass, of the Archbold Biological Station in Lake Placid, Fla. He will be accompanied by Geoffrey M. Tate, in charge of the expeditions' New York headquarters, which are located at the American Museum of Natural History, and Hobart M. Van Deusen, of the museum's Department of Mammals. The 1953 expedition is sponsored by the museum, Richard Archbold, Arnold Arboretum, and the Office of Naval Research.

The **Association of American University Presses** will distribute descriptive catalogues to more than 175,000 scholars on books newly published by the presses in the humanities, and the social, biological, medical, and physical sciences. The catalogues are expected to be mailed periodically, beginning in March.

A *Survey of Housing Research*, made by the **Building Research Advisory Board**, National Academy of Sciences, comprising a summary of recent and current housing research and facilities for conducting such research throughout the U. S., has been issued by the Housing and Home Finance Agency. The survey is available through the GPO at $3.00 a copy. Technical and social science aspects of housing problems are included.

Three awards were made by the **James F. Lincoln Arc Welding Foundation**, Cleveland, Ohio, in its 1952 bridge design competition, Welded Bridges for Steel Conservation. The first award went to Elwyn H. King, of Long Beach, Calif., the second to Kiser E. Dumbauld, of the Ohio State Highway Department, and the third was shared by Thomas Kavanagh, of New York University, and Leo Coff, of New York City.

The **National Science Foundation** has reported that grants and contracts for scientific research and development at nonprofit institutions made by federal agencies totaled $297 million in the fiscal year 1951 and $341 million in 1952, according to a preliminary analysis of information compiled with the cooperation of all agencies engaged in research and development activities. The information was obtained by broad scientific fields, and by character of work supported, including basic and applied research, development, and increase of research and development plant. The figures indicate that in 1952 there was an increase of 20 per cent over 1951 in funds expended for applied research and development, and a slight decrease for basic research.

The **Oberly Memorial Award for 1953** will be given for the best bibliography by an American citizen, in agriculture or related sciences, issued during 1951 or 1952. Seven copies of each entry, together with a letter of transmittal, should be addressed to the chairman of the committee, D. A. Brown, Agriculture Library, Mumford Hall, University of Illinois, Urbana, before *Apr. 15*.

Chemicals wanted by the **Registry of Rare Chemicals**, 35 W. 33rd St., Chicago 16, Ill., include: stannic selenide; silver thioarsenite; phenyl tellurium trichloride; selenium disulfide; lead ricinoleate; 2-thiolhistidine; 2,3,4-trimethyl quinoline; 1,3-diaminocyclohexane; 3,3′-dimethyl naphthidine; 4-aminopyridine; retene; 18-hydroxystearic acid; ellagic acid; lignoceryl alcohol; 1,2,3,4-tetracarboxybutane; D-cysteine; thymidine; galactoflavin; notatin; and mucin.

The **Society of American Foresters** has awarded the Gifford Pinchot Medal to Raphael Zon, of St. Paul; the Sir William Schlich Memorial Medal was given posthumously to Ellwood Wilson, of Knowlton, Que. Henri Kieffer, chief of the Forest Protection Service of the Quebec Department of Lands and Forests, received a plaque from the **Canadian Forestry Association** for forest conservation.

Four scientists were among the men selected by the **U. S. Junior Chamber of Commerce** as America's Ten Outstanding Young Men of 1952. They were: William H. Muller, Jr., of UCLA, for cardiac surgery; Ross Melvin Hedrick, of Monsanto Chemical Company, for work in developing the soil conditioner Krilium; Frank N. Piasecki, of Lansdowne, Pa., for pioneering in the helicopter industry; and Heinz Joseph Gerber, of Gerber Scientific Company, for the invention of the Gerber Variable Scale.

Technical Papers

A Computational Procedure for the Isotope Method of Brain Tumor Localization[1]

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G. E. Moore's original technique (*1*) for brain tumor localization by means of radioactive isotopes depends for accuracy very largely on the skill and experience of the individual investigator. To reduce this element of subjectivity to a minimum, we have developed what we believe to be a more objective analytical method which is giving us promising results. Thus far, we have examined 80 cases by this method; we feel, however, that the number is too small to allow statistical interpretation.

Better instruments are now being developed, but the work reported here was done with the following instrumentation: two bismuth-wall Geiger tubes—at first a long tube, 1 in. in diameter (RCL Mark 1, Model 12), and lately a shorter tube 1½ in. in diameter (RCL Mark 1, Model 13). The tubes were mounted in lead collimators 14 mm thick, and fixed in the cylindrical holes so that the resulting angle of collimation is about 30° (this is the angle between the axis and a direction of 50% sensitivity for a small source). The collimated tube is supported by a flexible dental x-ray arm. A standard decimal counting unit with automatic reset and preset time is used. The patient, when capable of sitting, is placed in a barber's chair provided with head and chin rests. Tagged material[2] (DIF or IHSA) is administered to the patient by intravenous injection.

The rate of elimination of radioactive substances from the brain is different for each part of the brain, and the empirically obtained correction factors used till now are inaccurate. The present method disregards the individual elimination differences from point to point and considers only artificial averages which we derive by taking two readings for each point, equally removed in time from the beginning and end of the total examination time. In practice, we use the 32 standard points developed by the original investigators (*1–3*). We take our first measurement over the glabella and then over the remaining 31 points of the skull until we reach the occipital midline point (I, PF-6, PF-4, PF-3, PF-5, F-7 F-5 . . . . . V, 0-3, 0-5, VI), these points describing a spiral; from here we repeat all measurements in retrograde sequence. In this way we have 2 counts for each point, each taken more or less equally spaced before and after the middle of the whole measuring period. Finally, we sum the 2 counts for each point, this figure becoming our value for the following computations.

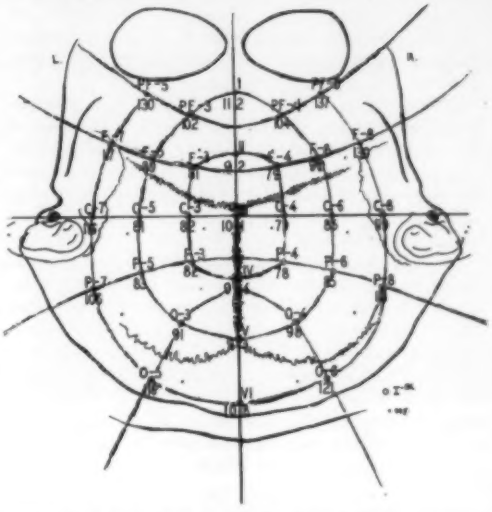

FIG. 1. Spread-out map of skull-surface. The 32 measurement points are shown with their standard designations used in isotope localization techniques, and their percentage activity (D^*) for the average normal skull.

By averaging data on 13 patients without organic brain lesion, we obtained an average pattern for the normal head. In order to obtain comparability to the normal skull pattern, we convert the absolute values of our counts to percentage values. We take the arithmetic average of our 32 values, and then express each individual value in percentage of this average. With each patient to be examined, we compare the individual results to the normal pattern and determine the following values:

C_H and C_L = pair of counting rates at 2 symmetrical points on the skull. H and L as subscripts stand, respectively, for the higher and lower counts. (Counts per unit time using any convenient unit of time.)

$A = 100\ (C_H - C_L)/C_L$ = observed asymmetry in counting rates, expressed as percentage of C_L.

$\overline{C}$ = average counting rate over the skull = average of all the Cs.

$D = 100\ (C/\overline{C})$ = percentage activity at each point.

$E = D - D^*$ = excess activity expressed in percentage (excess % activity). * Normal skull pattern.

$F = E_H - E_L$ = asymmetry in excess percentage activity (corrected asymmetry).

We have constructed a new map of the head which gives in a plane an approximate visualization of the three-dimensional relationship of the whole head (Fig.

[1] This work was started while the senior author was on an Isadore Abrahamson Neurological Fellowship, and is being continued under a research grant and fellowship from the Damon Runyon Memorial Fund for Cancer Research, Inc.

[2] The di-iodo^{131}-fluorescein (DIF) and iodinated human serum albumin (IHSA) were furnished by the Abbott Laboratories, North Chicago, Ill., under an allocation from the U. S. Atomic Energy Commission.

1). Such maps are used to record the observations and steps of computation. Each 15% increase of activity is arbitrarily taken as one unit and is represented as a line beginning at the point of measurement and drawn at the same angle as that of the collimated tube positioned at this point. (Increase of over 15% is considered as symptomatic of tumor.)

In the case of an increased radiation zone (characteristic of tumor), these lines, which are an index of the magnitude and the location of increased activity, intersect over the critical area. Taking into consideration the angle of collimation (30°), we can then fairly well delineate the location, shape, and size of the area of increased activity.

We have the impression, based on a few observations, that by taking into account not only the increased but also the decreased uptake values, other pathological brain processes could eventually be detected and evaluated by the method described (e.g., necrotic, ischemic areas, nontumoral lesions, etc.—processes where, probably because of circulatory or other deficiencies, the distribution of the tagged material is impeded, thus demonstrating in the involved area measurably less than normal radiation).

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Manuscript received July 28, 1952.

The Solubilization of 4-Dimethylaminoazobenzene (Butter Yellow) in Serum

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Many of the carcinogenic agents, including the azo dye 4-dimethylaminoazobenzene, are fat-soluble. As a vehicle for such substances emulsions of corn oil are used with polyglycerolester as emulsifier and stabilizer. In other experiments (*1*) rats were fed with a diet containing .058–.064% of 4-dimethylaminoazobenzene. It is a well-known fact that the mode of administration of the carcinogenic agent can have a decisive influence on the result; we were therefore looking for a technique to allow solubilization of such agents in homologous serum without any denaturation of the serum proteins.

To this end thick filter paper (Munktell No. 20/150, Grycksbo, Sweden) is thoroughly soaked in a solution of 12.5 mg% 4 dimethylaminoazobenzene in a 1:1 mixture of ethanol and ether. After drying the paper contains about 4 γ of the azo compound per cm². It is cut in strips of 40 × 7 cm, and .08 ml of normal human serum is placed on the middle of each strip. We arrange the apparatus for paper electrophoresis in a deep-cooling tank, keeping a constant temperature of 2° C and giving the effect of a closed atmosphere. Within 9 hr, 5–6 mg of serum protein can be separated, when 5 v/cm and 5–6 mamp are applied. The paper is wet with veronal/veronal sodium buffer of .06 ionic strength and pH 8.9. Of the two paper strips used simultaneously, one is afterwards stained with bromphenol blue; this strip serves as a guide for cutting off the fractions from the still wet unstained strip. The protein/azocompound is eluted from the cuttings with saline (.85%), the volume of each of the solutions being brought to about 3 ml. Then the optical density of the perfectly clear solutions is read in the Beckman spectrophotometer at 420 mμ and thereupon the content of the azo compound is calculated. The eluate from a protein-free paper cutting serves as a blank.

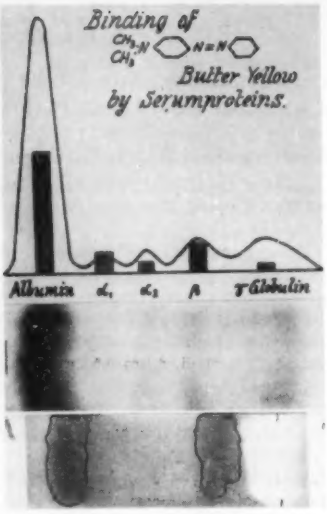

FIG. 1. Above: Serum protein fractions colored with bromophenol blue. Below: Same paper strip without coloring, showing the accumulation of butter yellow in the regions of albumin and β-globulin; blank space corresponds to site of γ-globulins.

The black columns in Fig. 1 show graphically the γ of azo compound bound to each serum protein fraction. The total of azo compound transported by this

TABLE 1

	Albumin	α_1	α_2	β	γ-Globulin
Serum fractions in rel %	63.2	4.0	7.1	9.6	16.1
Bound azo compound in γ	9.01	1.50	0.46	2.20	0.32
Bound azo compound in % of the total of transported azo compound	66	11	3	16	4
γ Azo compound/mg protein	6.7	4.2	3.0	11.0	0.9
Elution of Sudan red by isolated fractions of normal human serum protein[3] γ/mg protein	9.5		10.1	11.3	5.4

.08 ml of normal human serum amounts to 13.5 γ, so that a serum solution of .25 mg% results. Studies of carcinogenesis in rats are under way.

The last two lines in Table 1 allow a comparison of the amount of fat-soluble azo compound bound to the serum proteins by electrophoretic elution and the amount of lipophil Sudan red eluted from animal skin membranes (*2*). In both techniques the greatest solubilization takes place in the β-globulins, with albumin second. It has recently been shown that the β-globulins associate with cholesterol (*3*) and also with phosphatides (*4*).

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Manuscript received July 30, 1952.

Differential Migration of Rubber by Reversed-Phase Partition Chromatography[1]

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Differential migration of rubber has been accomplished by using silicone-treated paper as the stationary phase and certain viscous oxygenated solvents for the more polar, mobile phase. This is a reversal of the conventional procedure of paper partition chromatography in which the paper holds the polar solvent, ordinarily water, as a stationary phase. The reversed-phase technique has already been applied to other compounds of limited water solubility such as steroids (*1*), where the partition coefficents are greatly in favor of the mobile, nonpolar phase.

Levi and Cajelli (*2*) have shown that ethanolic benzene solutions of Hevea rubber, prepared from fresh latex, can be fractionated by passage through animal charcoal to give a series of eluates of progressively decreasing relative viscosities.

The present report discloses a procedure whereby natural and synthetic rubbers, and possibly other high polymers, can be chromatographed on treated filter paper to give patterns characteristic of their migration tendencies. These patterns are reproducible and, in some instances, can be related to various inherent physical properties of the polymer—e.g., molecular weight distribution, viscosity and polymer breakdown (Fig. 1).

Ordinary filter paper (Whatman No. 1) is cut into sheets 5 in. square and drawn through a 5% (by vol)

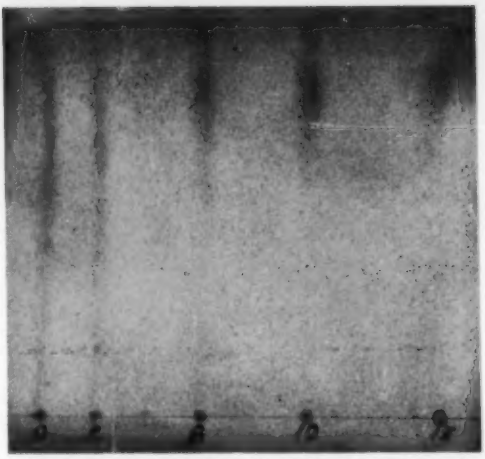

Fig. 1. The effect of physical breakdown by milling on the differential migration of rubber (deresinated guayule) on silicone-treated paper with cyclohexanone for solvent; numbers refer to minutes of milling.

solution of methyltrichlorosilane in benzene. The sheets are pressed to remove excess solution and are dried in an explosionproof circulating air oven at 65° C for 2 hr. This treatment produces a water-repellent paper which must be handled with care on account of its extreme brittleness.

Most of the experiments were carried out according to the microtechnique of Rockland and his co-workers (*3, 4*). The rubber is applied as microdrops of 1% solution in benzene to give a line of spots 0.5 in. from one edge of the paper sheets. Microwire loops (0.7 mm ID) provide a convenient means for applying one or more drops at each spot. Ascending chromatograms are obtained by suspending the paper sheets in covered museum jars containing sufficient solvent to wet the lower edge of the sheets.

The most satisfactory moving solvents have been cyclohexanone and mixtures of butyl diethyleneglycol acetate with cyclohexanone or xylene. The rate of solvent ascent with cyclohexanone is about 3 in./hr. When the moving solvent has traveled the desired distance (4 in.), the sheet is removed and dried in the circulating air oven at 65° C for 1 hr.

The spots or streaks of partitioned rubber are rendered visible by immersion of the paper for 15 min at room temperature in a .25% solution of oil blue NA (Calco) in 50% (by vol) aqueous ethanol.[2] A brief rinse in 50% aqueous ethanol destains the paper but leaves the rubber, and any other lipophilic substances, stained a bright blue or purple on a white background.

The use of oil blue NA as a stain for rubber in plant tissues has been recommended by Whittenberger (*5*) and Addicott (*6*). The intensity and permanency of

[1] The advice and interest of W. de Ráfols, Instituto Nacional de Investigationes Agronomicas, Madrid, Spain, and L. B. Rockland of this bureau are gratefully acknowledged.

[2] The oil blue NA should be first dissolved in a minimum of butanol before addition of the aqueous ethanol and then the resulting solution filtered.

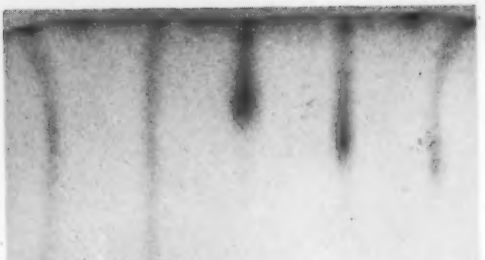

FIG. 2. Chromatograms of several types of elastomers on silicone-treated paper with cyclohexanone for solvent; guayule, Hevea, guayule (cont. 1% trichloracetic acid), Hevea (cont. 1% trichloracetic acid), GR-S.

color conferred to the rubber with this stain remain unsurpassed, to date, by any of the other means found for detecting the partitioned rubber. These other means include the use of Sudan III and Sudan IV (*7*), fluorescein-bromine spray (*8*), modified by the use of isopropanol as a wetting agent, and a spray or dip with .5% neutral aqueous potassium permanganate solution. Although all these reagents are of some value for the detection of rubber on untreated paper,[3] only oil blue NA has given consistently good results with silicone-treated papers. The hydrophobic character of these treated papers probably accounts for their decided "inertness" and lack of response to many of the familiar chromogenic sprays.

By means of the technique outlined above, differential migration patterns have been obtained for several natural and synthetic rubbers. In Fig. 2, where cyclohexanone was used for the mobile phase, comparisons are shown between Hevea (No. 1 smoked sheet), guayule (Salinas), and GR-S (standard). A definite resemblance may be seen in the migration behavior of Hevea and guayule. The somewhat greater mobility of guayule probably attests to a lower mean molecular weight, and a much smaller proportion of the poorly soluble gel fraction. The well-known effect of trichloracetic acid in dispersing the gel and otherwise decreasing solution viscosity is clearly demonstrated in this same chromatogram. The relatively lower mean molecular weight of GR-S is also reflected in its faster migration.

A chromatographic demonstration of the physical breakdown which results from the milling of crude rubber is shown in Fig. 1. A sample of high-quality acetone-deresinated guayule rubber (*9*) was systematically broken down by milling on closely set rolls. Samples were taken at the time intervals indicated, while the viscosity of the rubber was being reduced from an initial Mooney value of 95 to a final value of about 15. Taylor and Veith (*10*) have shown that for rubber broken down in a Brabender plastograph the Mooney viscosity is a semilogarithmic function of the masticating time. The differential migration patterns of Fig. 1 suggest that a similar relationship exists between polymer mobility and milling time.

The results presented here are intended mainly to demonstrate several ways in which partition chromatography can be a useful tool for the study of elastomers. The work is being continued and will be reported in greater detail at a later date.

[3] With untreated paper, much of the rubber either moves with the solvent front or remains at the origin. Migration in this instance is probably governed more by rate of dissolution than by partition.

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Manuscript received August 4, 1952.

Splash-Cup Dispersal Mechanism in *Chrysosplenium* and *Mitella*[1]

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Upon reading the stimulating account by Brodie (*1*) of the splash-cup dispersal mechanism in the Nidulariaceae and other groups of plants, the writer recalled looking down upon fruiting plants of the arctic golden saxifrage, *Chrysosplenium tetrandrum* (Lund) Th. Fries, at Chesterfield Inlet, Keewatin, and thinking how closely the erect, open capsules resembled the gemma cups of *Marchantia*. Examination of specimens collected at that time confirmed that the open capsule formed a deep cup with a flaring lip. Several plants were sent to Brodie, who agreed that the form of the cup appeared to be suitable for splash dispersal of the seeds.

Chrysosplenium americanum Schwein. was found in fruit some miles from Ottawa on June 4, 1952, a few hours after a heavy thunderstorm. The fully expanded

[1] Contribution No. 1198 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

capsules were all empty, but those only partly expanded had the full complement of 6–8 seeds attached to the two parietal placentae. Some of these plants were brought into the laboratory and placed in shallow water. After 24 hr, water drops falling from 3 ft caused seeds to be thrown horizontally up to 16 in. Some seeds had not completely abscissed, the plants were less turgid than in the field, and some difficulty was experienced in keeping the capsules as strictly upright as they are when growing naturally; otherwise it is probable that seeds would have been ejected for greater distances. *Chrysosplenium* should be easily grown in the greenhouse and would serve well to demonstrate the mechanism to students.

Chrysosplenium is well suited to this dispersal mechanism since it grows frequently in the splash from waterfalls, below moist cliffs, or in swampy woods where even a drizzling rain will fall from the trees in large drops.

On June 18 it was noticed that all capsules of *Mitella diphylla* L. that were approaching maturity had become vertically oriented even on a plant whose stem had been bent to the horizontal. Changed orientation of capsules on plants brought into the laboratory indicated that the vertical disposition is due to a phototropic response. Although the mature capsule of *M. diphylla* is somewhat flattened, rather than circular, in plan view, it has the form of a deep cup with a widely flaring lip and appears well adapted for splash dispersal of the seeds, which are held in clusters at the two ends of the cup. The seeds were all firmly attached at this time and no test could be made. It was not possible to visit colonies of this plant again until July 4. Heavy rain had fallen most of the preceding night, and the majority of capsules were empty. Plants with some immature capsules were collected and kept in water for 48 hr. The capsules were then subjected to water drops falling from distances of 3 ft 4 in. to 3 ft 8 in., depending upon the position of the capsules on the stalk. Although some capsules shriveled without the seeds abscissing, seeds were ejected from several of them, to distances of 4–29.5 in., the average distance being 11.6 in. With a free fall from the canopy of the mature deciduous woods in which *M. diphylla* commonly grows the seeds are presumably thrown appreciably further.

In the writer's experience the capsules of *Mitella nuda* always become erect at maturity, and this fact is borne out by examination of herbarium specimens ranging from Alberta to Nova Scotia. Less abundant material of *M. breweri*, *M. ovalis*, and *M. pentandra* suggests that the same is true of these species. The mature capsules of all these species have much the same form as those of *M. diphylla*, and it is probable that they function similarly.

Examination of available herbarium material indicates that in some species of *Heuchera* (e.g., *H. americana*) the mature capsules are more or less erect, whereas in others (e.g., *H. glabra*) they are not. In all species the capsules open apically but with a constricted throat, resulting in a deep vessel that probably functions as a very inefficient splash cup even when it is suitably oriented. It is probable that in the Saxifragaceae the splash mechanism originated in *Heuchera*. In the related *Tolmiea menziesii* the capsules are more or less erect but are more poorly shaped than those of most *Heuchera* spp. In *Saxifraga* the mature capsules are generally erect and form a somewhat better cup with less constriction at the throat, but too broad at the base for high efficiency. From *Heuchera* or *Tolmiea* there appear to have been two evolutionary lines: one leading to *Saxifraga* and related genera with axile placentation, but poorly developed splash cups; and one, perhaps through *Tellima*, to *Mitella* with parietal placentation, but efficient splash cups. *Chrysosplenium*, also with parietal placentation, has perhaps been derived from the latter line, but it is so reduced and specialized morphologically that its affinities are obscure.

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Manuscript received August 4, 1952.

Iron Content of an Insect Virus[1]

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Glaser and Chapman (*1*) reported that polyhedral bodies of *Bombyx mori* L. (silkworm) contained .496% iron, at a time when the nature of the polyhedral bodies and their relation to the virus itself were unknown. Bergold (*2*) first isolated and demonstrated the virus particles and showed that the polyhedral bodies of *B. mori* consist of about 95% noninfectious, homogeneous polyhedral protein with a molecular weight of about 378,000, and about 5% infectious virus material. In view of these findings it seemed of interest to investigate the distribution of iron in the polyhedral bodies.

The quantitative determination of iron was difficult since only small quantities (1–3) mg of virus were available. Comparison of the numerous methods described in the literature was undertaken, and finally the *o*-phenanthroline method of Saywell and Cunningham (*3*) and a wet-ashing procedure[2] were adopted. The following procedure was developed: To samples (up to 20 mg) containing 0.1–1.5 μg Fe, 2 ml of 9 *N* H_2SO_4 is added and dried for 5 hr at about 150° C. They are incinerated at 210° C for 3 hr, or until colorless (up to 7 hr), adding a total of 4–10 drops of

[1] Contribution No. 75, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

[2] A procedure for dry-ashing will be described by the senior author at a later date.

30% H_2O_2, depending on the sample size. After cooling, 4.7 ml of triple-distilled water, 0.4 ml 10% $NH_2OH \cdot HCl$, 0.4 ml *o*-phenanthroline, and 6.0 ml 5 *N* NH_4OH are added, resulting in a total volume of 12.0 ml, pH about 10. After 30 min the sample is cleared by high-speed centrifugation, and the absorption is measured in a photoelectric spectrophotometer equipped with a blue filter (*4*) and using cells with 5 cm light path. Amounts of 0.1–1.5 μg Fe can be determined with an accuracy of about ± 0.02 μg. Special care is necessary to avoid contamination.

The isolation and purification of the virus and polyhedral protein were carried out as described previously (*2, 5*). Samples of polyhedral protein and virus yielded the same results when washed repeatedly or dialyzed. Results are summarized in Table 1. Parallel

TABLE 1

IRON CONTENT OF POLYHEDRAL BODIES, POLYHEDRAL PROTEIN AND VIRUS OF *B. mori*

	Sample size (mg)	μgm Fe	μg Fe/mg	Mean % Fe
Polyhedral bodies	17.5	0.89	0.051	
	19.4	1.11	.057	
	8.2	0.41	.050	
	19.9	0.86	.043	0.005
	18.4	1.01	.055	
	13.9	0.70	.050	
	17.4	.82	.047	
Polyhedral protein	8.0	.45	.056	
	13.5	.89	.066	
	16.1	.96	.060	
	8.6	.42	.049	.005
	4.8	.28	.056	
	9.7	.53	.053	
	10.9	.59	.059	
	7.9	.45	.057	
Virus	2.4	.41	.172	
	1.2	.22	.185	
	1.2	.17	.143	.015
	2.4	.29	.122	
	3.3	0.52	0.157	

analyses by emission spectrography[3] were in good agreement. From Table 1 it can be seen that highly purified polyhedral bodies of *B. mori* contain only .005% iron instead of .496%, as reported by Glaser. It is of interest to note that the iron content of the virus is about three times as great as that of the surrounding polyhedral protein. The interpretation of the function of such a small amount of iron is probably not advisable. However, .015% still represents about 750 atoms of Fe per virus particle (particle weight 45.6×10^{-17} g), which would be sufficient for a cytochrome system. Since insect viruses are considered to be organisms (*6*), the iron content might be of some biological significance.

So far as is known, iron has never previously been reported as a constituent of any purified virus.

[3] The authors wish to express their appreciation to Dr. MacNamara and E. Herbert, of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, for the spectrographic results.

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Manuscript received December 23, 1952.

Syntheses of Methylamine-C^{14} and Diazomethane-C^{14} [1]

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Easily performed procedures for the preparation of the useful synthetic intermediates methylamine-C^{14} and diazomethane-C^{14} in yields, respectively, of 98% and 54% have been used with excellent results in these laboratories over the past two years.

Potassium cyanide-C^{14} was prepared by a modification of the Loftfield (*1*) procedure which utilizes the reaction of carbon dioxide and ammonia with a potassium mirror at 630° C. The sealed tubes were made of quartz, which eliminated the strains to which Pyrex is subject. No tube failure has occurred since this change in over a hundred experiments. The formation of the potassium mirror was accomplished simply by warming the lower end of the evacuated tube containing the potassium with a small burner while blowing a stream of cooled air on the upper walls of the tube. The nozzle of the air tube was directed by hand so as to cause condensation of the potassium progressively downward from the top.

The cyanide was readily reduced at atmospheric pressure by hydrogen and platinum oxide in dilute sulfuric acid solution. A 98% yield of methylamine-C^{14} hydrochloride was obtained by making the hydrogenation solution basic with potassium hydroxide and distilling the volatile base into a receiver containing hydrochloric acid.

(Methyl-C^{14})-urea was quantitatively obtained by heating the distillate (vol reduced to 5 ml) for 30 min with a slight excess of potassium cyanate in a boiling water bath. The procedure of Arndt and Amende (*2*) was more easily adapted to the small-scale preparation required than the methods for the preparation of diazomethane precursors involving the reactions of methylamine hydrochloride with urea (*3*) and of methylamine with mesityl oxide (*4*). The purified product was eluted from the dried reaction residue with boiling anhydrous methanol.

N-nitroso-N-(methyl-C^{14})-urea was obtained by the usual procedure, although with inverse addition of the reagents. It was filtered and freed of inorganic material by elution with anhydrous methanol at room

[1] This document is based upon work performed under Contract Number W-7405-eng.-26 for the Atomic Energy Commission at the Oak Ridge National Laboratory.

temperature. The fluffy solid produced by evaporation of the eluate was obtained in 77% yield from sodium cyanide-C^{14} (radiochemical yield, 76%).

Diazomethane was prepared by treating an ether suspension of the nitrosomethylurea with 50% potassium hydroxide for a short time and then codistilling the ether and product into dry-ice cooled traps containing reactants. The yield was 54% from sodium cyanide-C^{14} as determined by radiochemical analysis of methyl-C^{14} 3,5-dinitro-2-methyl benzoate (chemical yield, 60%). The radiochemical analyses were accomplished by oxidation of aliquots of the radioactive substance to carbon-C^{14} dioxide, the activity of which was determined by means of a vibrating Reed electrometer (*5*).

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Manuscript received July 29, 1952.

Removal of Thiamin and Riboflavin from Milk for Dietary Use[1]

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In planning palatable experimental diets low in riboflavin and thiamin it is difficult to include adequate amounts of protein, calcium, and phosphorus from natural food sources. Recommended diets for children and adolescents, in particular, ordinarily contain large amounts of milk with its accompanying B vitamins.

Moody, Hauge, and Lundquist (*1*) have reported treatment of milk with florisil[2] in order to obtain a low-riboflavin milk for calf feeding. The same principle was used in this laboratory for removal of most of the riboflavin and thiamin from whole milk. The method uses florisil as an alternative to procedures involving irradiation of dry or whole milk (*1, 3, 4*). Main advantages of the florisil method are (1) treatment is rapid, (2) removal of thiamin and riboflavin is fairly complete, (3) there are no irradiation products, and (4) the taste of the milk is unaltered.

Two cotton gauze milk filter pads, such as are used by milk producers, are placed in a 6-in. Buchner funnel and sealed with water. Three hundred g 60/100 mesh florisil suspended in 2% acetic acid is poured into the funnel and allowed to drain (without suction). The florisil is washed three times by filling the funnel with water. This washing serves to remove both the excess acid and the florisil dust which cannot be retained by the filter pads.

Three gallons of whole, homogenized milk is then delivered from a separatory funnel into the Buchner at the rate of filtration. A small circle of glass should be laid on the florisil below the end of the separatory funnel to avoid formation of a hole in the florisil. Collection is begun as soon as all the water appears to have been expelled.

Filtration of 3 gal milk without suction requires 90 min; 87–91% of the riboflavin and 95–100% of the thiamin are removed. Removal of calcium, phosphorus, and protein was found to be negligible. Adsorption in absolute amounts of these substances may well be as great as or greater than that of riboflavin and thiamin, but, as the calcium, phosphorus, and protein concentrations in milk are of a much greater magnitude, the fraction of the whole which is removed is not enough markedly to impair the value of the treated milk as a source of these nutrients. Only the thiamin, riboflavin, calcium, phosphorus, and nitrogen contents of the treated milk were investigated. The possibility that certain of the other vitamins present are also removed to greater or less extent is recognized. The treated milk should not be assumed to be a source of any nutrient until this assumption is justified by analytical results.

Either aseptic procedures should be used throughout, or the treatment of the milk should be followed by pasteurization.

Because of the cost of florisil, it may be desirable to recover and reuse it. After the florisil has been washed free of milk, it is washed with 20% pyridine in 2% acetic acid, in order to elute the adsorbed vitamins. The pyridine solution is washed away with water, and the florisil is then heated overnight at 600° C (*5*). It is not necessary to remove the pyridine exhaustively by washing. In the course of the high-temperature treatment, the florisil will be freed of all pyridine and of any other residual materials that can be distilled or carbonized. Adsorptive power of the reclaimed florisil was found not to differ from that of the unused product. It has not been determined whether the florisil loses its adsorptive properties after being repeatedly reused and reactivated.

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Manuscript received July 21, 1952.

[1] Supported in part by a contract sponsored by the Bureau of Human Nutrition and Home Economics, USDA.

[2] Florisil is a synthetic magnesium silicate obtainable from the Floridin Company, Warren, Pa. Particles which might conceivably remain in the treated milk would not make the milk unfit for human consumption. This compound and other fuller's earth–type materials are used for purification of pharmaceuticals and medicinally as antiacids and for treatment of peptic ulcers, etc. (*2*).

The Protective Effect against X-Irradiation of Methyl Lineolate in the Rat[1]

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In previous work from this laboratory (*1*), it was shown that rats receiving a diet containing as small a proportion of cottonseed (Wesson) oil as 2% were much more resistant to injury from x-irradiation than were animals on a fat-free regimen. Although no differences in survival could be noted when the rats receiving 0 or 30% of cottonseed oil in the diet were subjected to a single lethal dose of 650 r and 850 r, a marked variability in survival time obtained when animals on these dietary regimens were subjected to repeated sublethal doses of x-irradiation in amounts of 300 r at weekly intervals. The groups in which fat was present in the diets lived for a significantly longer period after being subjected to x-irradiation than did the control group receiving a fat-free ration.

In addition to the level of fat, which is an important factor in protection from x-irradiation, sex has likewise been shown to play a significant role. In one series of tests (II) carried out on mature rats, the cottonseed-oil regimen protected the male and female rats equally well. On the other hand, in another series (III), in which vigorous young animals received diets containing 0, 2, or 30% cottonseed oil, the protective effect of the cottonseed oil was much less marked in the female than in the male animals.

The length of survival was found to be the most satisfactory index in evaluating the effectiveness of the several dietary factors. Thus, in Series II, the male rats receiving 15% or 30% of cottonseed oil in their diet survived 70 ± 6.1 or 63 ± 7.1 days, respectively, as contrasted with a mean of 34 ± 3.3 days for those on the fat-free regimen. Corresponding averages for the female rats were 76 ± 7.0 days (15% oil), 69 ± 5.3 days (30% oil), and 39 ± 4.3 days (0% oil). In Series III, the variations were equally significant for the males; the survival times averaged 65 ± 3.0 days and 67 ± 3.2 days for the rats on the 2% and 30% cottonseed oil diets as contrasted with a value of 51 ± 3.1 days for the control male rats. On the other hand, although the averages for the females were similar to those for the males on the experimental diets (67 ± 2.6 days for 2% oil, 62 ± 3.4 days for 30% oil), they are not significantly different from the results on the control rats, which had a mean survival time of 61 ± 3.6 days.

The effectiveness of the fat diets in protecting the animals is further indicated by the fact that, coupled with the increased survival times, the average exposure to x-irradiation was considerably higher in the groups receiving fats than it was in the case of the animals on the fat-free diet. Although the hemoglobin level and leucocyte count decreased in all cases for animals exposed to x-rays, it was found that the results obtained by means of these data were too irregular to be satisfactory indices of the protective effect.

Because of the small amount of fat required to exert a protective action on irradiation damage, it seemed possible that the therapeutic agent in cottonseed oil might be the essential fatty acids. On the basis of an average food consumption of 10 g daily, this would represent an intake of 200 mg cottonseed oil/day. Since cottonseed oil contains about 50% linoleate (*2*), the daily ingestion of 100 mg of linoleate would thus be indicated. Although the optimum dose of linoleate for male rats probably exceeds 200 mg/day (*3*), definite growth responses can be demonstrated when amounts of linoleic acid as low as 5 mg/day are administered. In the case of female rats, the optimum daily dose probably approximates 50 mg (*4*). It is therefore evident that the linoleate intake of the rats receiving the 2% cottonseed-oil diet is within the physiological range. The present experiments were designed to demonstrate whether a protective action against x-irradiation, similar to that noted for cottonseed oil, would be exhibited by purified methyl linoleate. In order to obtain further evidence of the effectiveness of the essential acids, the dose chosen was 10 mg/day, which was high enough to produce an increase in body weight on a fat-free diet, but far below the optimum level for growth.

The tests were carried out on male and female rats from our stock colony which were 5–6 months old at the start of the present tests. They were placed on essential fatty acid-free diets at weaning and were continued on these diets until fat-deficiency symptoms were noted. The animals were considered to be depleted when a sustained drop in body weight was maintained over 2 weeks, or when the total weight gain over a 3-week period did not exceed 4 g. The time required for the deficiency symptoms to develop was 9–12 weeks. The fat depletion diet contained vitamin-test casein, 20%; sucrose, 71.64%; cellulose (Solka-Floc), 4%; Osborne-Mendel salt mixture, 4%; and synthetic B vitamins, 0.36%.[3] Hydrogenated coconut oil was added to this diet in amounts of 0, 5, 15, or 30%, replacing a corresponding amount of sucrose. A fat-soluble vitamin mixture was administered orally twice each week. The doses per day were as follows: α-tocopherol, 0.1 mg; vitamin A, 30 μg; and vitamin D, 100 IU.

After depletion, the rats were all continued on the fat-free basal diet for an 8-week assay period. At the termination of this interval, the animals were as-

[1] This investigation was supported in part by a research grant from the Atomic Energy Commission (No. AT(11-1)-113). Communication No. 319 from the Department of Biochemistry and Nutrition, University of Southern California.

[2] We wish to thank Merck & Co. for the B vitamins (except folic acid and biotin), the Lederle Laboratories for folic acid, and Hoffmann-LaRoche for the biotin.

[3] The composition of the water-soluble vitamin mixture in mg/100 g of the diet was as follows: thiamine chloride hydrochloride, 7.2; riboflavin, 2.74; pyridoxine, 2.7; calcium pantothenate, 6.0; nicotinic acid, 6.0; inositol, 50.0; p-aminobenzoic acid, 60.5; folic acid, 1.0; biotin, 0.25; choline chloride, 200; vitamin B_{12}, 0.005 (5γ); ascorbic acid, 20.0; and menadione, 0.5. The total weight of these supplements is 0.357 g.

TABLE 1

SURVIVAL OF MALE AND FEMALE RATS ON A FAT-FREE DIET AND SUBJECTED TO SUBLETHAL DOSES OF X-RAYS WITHOUT OR WITH SUPPLEMENTATION WITH METHYL LINOLEATE IN DOSES OF 10 MG DAILY

Category	Wks on experiments	Cumulative exposure to x-irradiation (r)	Male rats		Female rats	
			No linoleate	10 mg linoleate daily	No linoleate	10 mg linoleate daily
No. of rats at start	—	—	36	35	35	37
Av wt at start (g)	—	—	223.4	178.6	253.3	201.1
Mortality, %, and number (in parentheses)	1	300	0	0	0	0
	2	600	2.8(1)	0	0	0
	3	900	5.6(2)	0	0	0
	4	1200	22.2(8)	0	8.6(3)	0
	5	1200	30.6(10)	5.7(2)	20.0(7)	5.4(2)
	6	1200	36.1(13)	11.4(4)	28.5(10)	8.1(3)
	7	1500	47.2(17)	17.1(6)	39.9(14)	13.5(5)
	8	1500	55.6(20)	22.8(8)	45.6(16)	24.3(9)
	9	1800	61.1(22)	25.7(9)	59.9(21)	32.4(12)
	10	1800	69.4(25)	31.4(11)	62.7(22)	32.4(12)
	11	2100	80.5(29)	39.9(14)	71.3(25)	43.2(16)
	12	2100	86.1(31)	54.2(19)	74.1(26)	48.6(18)
	13	2400	88.9(32)	59.9(21)	85.5(30)	56.7(21)
	14	2400	91.6(33)	59.9(21)	85.5(30)	56.7(21)
Av survival time (days)*	—	—	53.4 ± 3.8	74.7 ± 3.3	58.5 ± 4.0	74.8 ± 3.3
MD:SEMD†	—	—	—	4.16	—	3.42
Av exposure (r)	—	—	1408	2040	1766	2059

* Including standard error of mean calculated as follows: $\sqrt{\Sigma d^2/n-1}/\sqrt{n}$ where d is the deviation from the mean and n is the number of observations.

† Mean difference : standard error of mean difference when results on control and experimental group are compared. When this value exceeds 3, the differences are significant.

signed to the two groups employed in the current tests. Both groups received the same basal fat-free diet that had been used in the depletion and assay periods, except that the coconut oil was replaced by sucrose during the assay period. One group received 10 mg of methyl linoleate daily by mouth, by means of a tuberculin syringe with a blunted needle. The fat-soluble vitamin mixture was administered twice weekly. All rats were subjected to 300 r of x-irradiation weekly for 4 weeks, after which the same dose was given once in 3 weeks or on alternate weeks until a 2400 r exposure had been completed over a 14-week period. The rats were housed in individual cages and were weighed weekly. Food and water were given *ad lib.* The x-ray apparatus employed has been described earlier (*1, 5*). The results of the tests are summarized in Table 1.

The increased survival time of the male and female rats receiving 10 mg of methyl linoleate daily is significantly greater, from a statistical standpoint, than that of the rats receiving the basal fat-free diet without linoleate. Moreover, the survival time for the linoleate-supplemented rats was increased despite the fact that the average exposure to x-irradiation was 45% and 17% greater for the male and female rats, respectively, which were supplemented than for the unsupplemented controls. Had equal doses of x-irradiation been given to the two groups, wider variations in survival time would have been noted. Moreover, the method of calculation is such as to indicate minimum differences. Since the experiment was terminated after 14 weeks, the survival time of all rats still alive was calculated as 98 days. Had the experiment been allowed to continue without further irradiation, and if the actual survival time had been used for the calculations, the discrepancies in means between the two groups would have been greatly exaggerated. This is due to the fact that, at the termination of the experiment, only 8 rats (3 male, 5 female) of the unsupplemented group were still alive, whereas 30 rats (14 male, 16 female) of the group receiving 10 mg of methyl linoleate had survived.

The reason for the beneficial effect of methyl linoleate on irradiation injury is not immediately clear. It is known to be important, however, in the nutrition of the epidermis, since an eczematous condition of the skin and scaliness of the tail occur in essential fatty acid deficiency. It is of considerable interest that a number of substances that have proved efficacious in irradiation injury, among which are cystine, ascorbic acid, and vitamin P (*6*), are likewise substances of considerable importance in the metabolism of the epidermis.

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Manuscript received August 6, 1952.

Comments and Communications

Weight and Body Temperature in Mammals

THE recent statement (*1*) that a previously described relationship between weight and body temperature (*2*) was "not valid," and that "the apparent correlation resulted from an inadequate representation of data," deserves comment.

The paucity of data in the literature makes it difficult to correlate comparative body temperatures with other factors in a thorough and completely satisfying manner. This deficiency has been due in part to the fact that many reports on metabolic rates of various species neglect to record necessary data on body temperature of the animals under study (*3, 4*). Nevertheless, a large number of well-controlled studies on laboratory and domestic animals, and the sporadic data on exotic species make it apparent that the described relationship between weight and body temperature *is* valid. This becomes clear in a brief review of some of the literature reporting the body temperature of smaller mammals, listed below in order of increasing weight.

In a painstaking study Kendleigh (*5*) has shown the *basal* body temperature of shrews (*Blarina brevicauda talpoides*) (10 g) to approximate 34.7° C, and that of the white-footed mouse (*Peromyscus maniculatus gracilis*) (20 g) is averaged at 36° C. The careful work of Herrington (*6*) gives the average basal temperature of mice (20–30 g) as 36.5° C. Bats (30 g) are reported as also showing this temperature (*7*). The chipmunk (*Tamias striatus*) (150 g) has a basal temperature of 36.5° C (*5*). Ground squirrels (150–250 g) are reported as averaging 37° C (*8, 9*). The rat (300–400 g) is generally agreed to have an average body temperature about 37.5° C (*6, 8, 10–13*). The average temperature for the guinea pig (400–750 g) is given as ranging from 38° to 39° C (*6, 8, 12, 14, 15*). For the rabbit, cat, and dog the average is 39° C or slightly higher (*8, 12, 16–23*). Data on body temperatures of nondomestic animals are necessarily limited and are commonly influenced by exertion and anxiety on the part of the animal, and often of the observer.

The average temperatures of mammals in the 5–100-kg range show considerable variation, as indicated in our original figure (*2*), but all are 37.5° C or more. The very large mammals have temperatures below this value. Thus the elephant seal, with a weight of about 1400 kg, has a temperature of 35° C (*24*). Elephants are reported consistently to have body temperatures of 35.5°–36.5° C (*8, 12, 25, 26*). All these data fit well with the postulated relationship. Inspection of Morrison and Ryser's Fig. 1 reveals a satisfactory relationship for weight and body temperature for carnivores and primates. Computation of statistical trends for other single orders, such as Morrison and Ryser have attempted, must await the accumulation of considerably more data than they present.

The great variability of body temperature, particularly under conditions of disease and exertion, makes it necessary to use judgment in the utilization of data. Publication of all available data obtained under these nonbasal conditions, calculation of averages, and even statistical handling with determination of the standard deviation of the means and the *t* values, do not assure an adequate approximation to the resting temperature level. Thus, as Wislocki (*8*) has pointed out, "the temperature readings [on whales] are all from stranded individuals and in all likelihood do not represent the normal temperature of these animals." Just why Morrison and Ryser selected two values from the 40 listed by Zenkovich (*27*) on dead whales, rather than the five values on living but moribund whales is difficult to fathom. These values obviously cannot be accepted as evidence against the weight-temperature relationship. Similarly, Morrison and Ryser (*1*) have selected a single datum on the shrew from the four listed by Kendleigh (*5*) and have neglected to note that this was a struggling animal that died immediately afterward. Kendleigh (*5*) recorded that in the course of a few minutes of struggling, the body temperature of small mammals may rise from a resting level slightly over 35° C to as high as 39.5° C. Since no statement concerning the conditions of measurement of the body temperature of their small mammals was made by Morrison and Ryser (*1*), the validity and significance of their data must be held *sub judice*.

Attention is called to an error in the weight, and probably in the temperature, given for the manatee (*2*). These sea cows may weigh as much as 1000 kg. Only two reports (38.9° and 40.0° C) were found on these species, both apparently taken at the time of death (*28*). The difficulty in obtaining resting temperatures of these animals, as well as of other animals being driven to slaughter, has been pointed out by Hanna (*29*).

It must be borne in mind that our knowledge of basal mammalian temperatures is so fragmentary that scientific evidence damaging to the weight-temperature assumption may yet accumulate on further inquiry.

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Book Reviews

The Exact Sciences in Antiquity. O. Neugebauer. Princeton, N. J.: Princeton Univ. Press, 1952. 191 pp. and 14 plates. $5.00.

Despite all the lip service given nowadays to general education, rarely is science assigned more than a minor technical role of "information, please." Any integration of science with culture is supposedly the responsibility of self-styled humanists, who rely primarily upon the scholarship of other humanists. It is not surprising, therefore, that the historical interrelationships between science and civilization are somewhat distorted. What is needed as a basis for any generalizations are researches by scientifically trained historians and/or by historically trained scientists. Otto Neugebauer belongs to this class. As he gratefully remarks in the preface, with respect to its dedication to Richard Courant: "I owe him the experience of being introduced to modern mathematics and physics as a part of intellectual endeavor, never isolated from each other nor from any other field of civilization."

The present book, a modified form of the author's 1949 Cornell University "Messenger Lectures on the Evolution of Civilization," is a semipopular, scholarly account of mathematics and astronomy in Babylonia and Egypt in their relationship to Hellenistic science. It is based upon the author's belief that "The investigation of the transmission of mathematics and astronomy is one of the most powerful tools for the establishment of relations between different civilizations." The author modestly concludes his account with the remark: "Perhaps it is vain to hope for anything more than a picture which is pleasing to the constructive mind when we try to restore the past."

After a review of the early history of number symbols, the author discusses the characteristic features of mathematics in the Old Babylonian period of the Hammurabi dynasty. To an amateur, such as myself, nurtured upon classical tradition, it is startling to learn of the highly developed numerical skills utilized at this time. Tables still exist containing squares and square roots, cubes and cube roots, and sums of squares and cubes. Special types of cubic equations were solved; particular exponential functions (for the computation of compound interest) were used; arithmetical progression was known. From a Seleucid text one finds "the correct application of the 'quadratic' formula for the solution of quadratic equations."[1] Their computed value of 1.414213 (actually 1.414214) for the square root of 2 was still used by Ptolemy. In connection with such numerical work, "The determination of the diagonal of the square from its side is sufficient proof that the Pythagorean theorem was known more than a thousand years before Pythagoras." Even the "fundamental formulas for the construction of triples of Pythagorean numbers were known. . . . Geometrical concepts play a very secondary part in Babylonian algebra."

After this fascinating revelation of "a level of mathematical development which can in many aspects be compared with the mathematics, say, of the early Renaissance," it is somewhat of a letdown to read about the status of early Egyptian mathematics and astronomy. For example, "Egyptian mathematics did not contribute positively to the development of mathematics." One of the major results, however, was a "deeper insight into the development of computation with fractions." The whole process was entirely additive. In the case of astronomy there is apparently only one very beneficial influence—namely, a calendar with a fixed time scale and no intercalations, which became the standard astronomical system of reference through the Middle Ages. "This calendar, indeed, is the only intelligent calendar which ever existed in human history." Incidentally, one "Egyptian contribution to astronomy is the twelve divisions of daytime and of night." Noteworthy by its omission in the text proper is any reference to the astronomical or mathematical significance of the Pyramids. The author con-

[1] "One of the tablets from Susa implies even a special problem of the eighth degree."

cludes this lecture with the interesting judgment that "Ancient science was the product of a very few men; and these few happened not to be Egyptians."

After this interlude we find ourselves searching for clues to ferret out the mysteries of Babylonian astronomy. Right at the start we are emphatically warned that "mathematical theory played the major role in Babylonian astronomy as compared with the very modest role of observations, whose legendary accuracy also appeared more and more to be a myth." The Babylonians, of course, were primarily interested in lunar, solar, and planetary phenomena close to the horizon. We are reminded that sandstorms frequently obscure the desert horizon so that "the almost proverbial brilliance of the Babylonian sky is more a literary cliché than an actual fact." Eclipses and occultations, on the other hand, are usually observable under more favorable conditions. Hence, "Ptolemy states that practically complete lists of eclipses are available since the reign of Nabonassar (747 B.C.), while he complains about the lack of reliable planetary observations. . . . Not a single text is known which could be called a wholly observational record. . . . We know so little about the underlying empirical material which was so skillfully applied to provide the basic parameters of a real mathematical theory." Incidentally, the zodiac (first mentioned in a Babylonian text of 419 B.C.) was invented to assist in the description of celestial motions. "Arithmetical progressions were skillfully utilized for the prediction of lunar phenomena with an accuracy of a few minutes." Babylonian astronomy was fully developed at about 300 B.C.

The last chapter, on the "Origin and Transmission of Hellenistic Sciences," is a natural climax for this challenging story. By this time we are conditioned to expect something like the following:

> If modern scholars had devoted as much attention to Galen or Ptolemy, they would have come to quite different results about the remarkable quality of the so-called Greek mind to develop scientific theories without resorting to experimental or empirical tests. . . . Plato's role has been widely exaggerated. . . . His advice to astronomers to replace observations by speculation would have destroyed one of the most important contributions of the Greeks to the exact sciences.

On the other hand, "the traditional stories of discoveries made by Thales or Pythagoras must be discarded as totally unhistorical."

Professor Neugebauer cites evidence for his conclusion that the mathematics of the Hellenistic period is part of an unbroken tradition from earliest ancient history to modern times. On the other hand, "The Elements of Euclid concern, with very few exceptions, a purely Greek development in a sharply defined direction." The axiomatic style of Eudoxios is to be sharply differentiated from that of Ionia and of southern Italy. Nor can credence be given to anyone claiming "repeated land measurements responsible for geometry;" it is "completely impossible to test any such hypothesis." In Hero's later degenerate geometry, indeed, one finds a reflection of the arithmetical or algebraic tradition of Mesopotamia.

The history of Greek astronomy presents a more involved problem than the history of mathematics, with its unique contribution over a relatively short period. For example, "there existed 'linear methods' of far wider extent than one could possibly have deduced from the silence of Ptolemy and his commentators." Furthermore, "essential parameters ascribed by Ptolemy to Hipparchus are identical with the corresponding parameters of the Babylonian theory." Hipparchus, indeed, used both geometric and arithmetic (linear) methods. The latter were particularly used also by astrological authors for horoscopes. Hence one finds "astrology . . . an exceedingly helpful tool for the transmission of Hellenistic thought." The Hindu and Babylonian contact, moreover, has been made primarily through the Greeks. Accordingly, "we stand today at the beginning of a systematic investigation of the relations between Hindu and Babylonian astronomy, an investigation which is bound to give us greatly deepened insight into the origin of both fields."

One of the small pleasures I personally derived from this stimulating book was the explanation of the arrangement of the Greek planetary week, which we still use today. It is "totally misleading when this order is called Chaldean in modern literature." Something new about something old! I strongly recommend this important summary to every scientist, particularly mathematical and physical scientists, and to every so-called humanist, particularly historians and philosophers. The excellent bibliography, notes, and references are instructive for mature specialists.

There are, of course, minor blots on this excellent record—for example, the spelling of Greek names. I felt somewhat unhappy, too, about the chronological table at the end. To be sure, "dates are only approximate." But why 1670 for Newton? What is the basis of the approximation? My major critical remark concerns the title itself. What are "the *exact* sciences in antiquity" or "the modern *exact* sciences" mentioned in the text? Are mathematics and astronomy to be regarded as a special single category of the sciences? As a physicist I would merely note the following predominant features: logic for mathematics, observations for astronomy, and experiments for physics. Webster's dictionary cites the phrase the "exact sciences" as an example of a usage of the word "exact" for denoting "capable of great nicety, especially in measurements." Perhaps this meaning might be applicable to some branches of physics, but not to most of astronomy, and certainly not at all to mathematics. In the last instance one might substitute an alternate dictionary meaning, namely, rigorous—a fighting word among modern mathematicians. I would personally prefer to give up this outmoded terminology.

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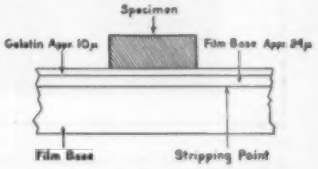

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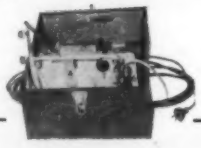

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Tables of Chebyshev Polynomials $S_n(x)$ and $C_n(x)$. National Bureau of Standards. Washington, D. C.: GPO, 1953. 161 pp. $1.75.

Taxonomy of the Karroo and Red-back Larks of Western South Africa. Zoology, Vol. I, No. II. J. D. MacDonald. London: British Museum (Natural History), 1953. 30 pp. + 3 pls. 10s.

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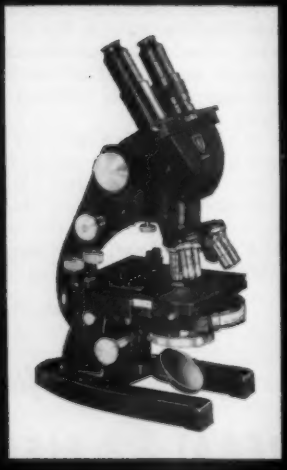

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